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Use of Geographic Information System (GIS) For the Analysis of Electricity Power Distribution in Bukuru Town, Plateau State, Nigeria

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Abstract: *Electricity is pivotal to the development of nations. Adequate power supply is an unavoidable prerequisite to any nation's development; its use is directly correlated with healthy economic growth. This study undertakes to develop a decision Support System using the Geographic Information System (GIS) to aid the electricity power supply in Bukuru Town, with particular reference to the distribution transformers of the Bukuru business unit, Jos Electricity Distribution Company, Plateau State. On the basis of these, the study involved capturing the geometric and attributes data of the electrical facilities and creating a geo-database for the features in each of the distribution transformers and the feeder stations. It also involved mapping the existing transmission network, the feeder station and the distribution transformers in the study area, The study revealed the geospatial distribution of electricity power for the distribution transformers in Bukuru Town, Primary distribution lines carry the medium voltage power to distribution transformers located near the customer's premises, distribution transformers again lower the voltage to the utilization voltage of household appliances and typically feed several customers through secondary distribution lines at the same voltage. The study clearly indicates the capability of spatially enabled information system in the management of electricity power distribution system.*

Keywords:*GIS, Electricity, Power Supply, Distribution Systems.*

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I. Introduction

1.1. Background

Adequate power supply is an unavoidable prerequisite to any nation's development. Electricity generation, transmission and distribution are capital-intensive activities requiring huge resources of both the funds and capacity. In the prevailing circumstances in Nigeria, where funds availability is progressively dwindling, creative and innovative ideas are necessary to address the power supply problem (Arinze, 2014). Electricity is pivotal to the development of nations. Its use is directly correlated with healthy economic growth(Kaseke & Hosking, 2013). Nigeria is one of the most populated countries in Africa but only about 40% of the people are connected to the energy grid. The people who actually have power experience difficulties, up to 60% of the time (Aliyu, Ramli, & Saleh, 2013). Aliyu, *et al* (2013) claim that blackouts cripple the industrial sectors. For example, outages in this area of the world also have implications for the mining industry. When power fails, workers may be trapped in the mines, so as soon as there is a risk of failure, the operations are shut down, which leads to economic difficulties. Lack of electricity also causes problems for agriculture. Most irrigation lines are run by the electricity, so when the power is cut out, then the crop yield decreases(Kaseke & Hosking, 2013).

There are approximately 162 million people living in Nigeria. Of these people, about 70% of them are living below the poverty line of one dollar a day (Ejiogu, 2013). This makes the population at higher risk of having a larger environmental impact on their surroundings because they need the supplies (Middleton, 2018). The people in Nigeria near the oil and natural gas reserves often vandalize, or steal oil, because they feel like they should have a share in the oil that is coming from their area of the country (U.S Energy Informaton Administration, 2014). In Nigeria the shortfall of electricity leads to overuse of generators for energy. It is estimated that about 30% of the energy is produced in this manner(U.S Energy Informaton Administration, 2014). Nigeria has a reputation of having one of the most corrupt governments in the world, about 61% of the people in Nigeria live below the poverty line and the unemployment rate is 9.9% (NBS & UNICEF, 2017).

Alternative forms of energy are not used probably because of the availability of oil in Nigeria, as it has the world's seventh largest oil reserves (Ejiogu, 2013).

Currently Nigeria uses four different types of energy: natural gas, oil, hydro, and coal (Aliyu et al., 2013). The energy sector is heavily dependent on petroleum as a method for electricity production which has slowed down the development of alternative forms of energy (Aliyu et al., 2013). Three out of the four above resources used for energy production in Nigeria are linked with increasing greenhouse gas emissions: coal, oil and natural gas, with the coal emitting the worst of the three (Middleton, 2018).

According to the World Commission on Environment and Development, (1987), the importance of sustainability in energy is the ability to preserve its use, the importance of energy in living standards and for economic development and the significant impacts that energy systems and processes have had and continue to have on the environment. Nigeria needs to invest in sustainable resources because of the obvious signs that it will be strongly impacted by environmental change such as desertification, droughts, flooding, and water shortages. The biggest blow to Nigeria would be the low lying areas that contain many of their natural resources being flooded if ocean levels rise as predicted (Gujba, Mulugetta, & Azapagic, 2011). Since further development of hydro-electricity does not seem practical because of the dependence on the seasons for the amount of water supply (Ajayi, 2009).

Nigeria's epileptic power supply has taken a turn for the worse in recent months. Despite investing over $30 billion in the sector in the past 15 years, the total electricity supply as at today is less than a mere 1,400 megawatts (MW) for a country of over 170 million people. As a result, the citizens and businesses have resorted to the use of electric generators to the point where some industrial experts are placing the frontal cost, including imported fuel, as high as the size of the annual national budget (Ogbonnia, 2015) Electricity power supply determines the economic strength of nations, hence, in the absence of this electricity, and then weaknesses are felt around the developmental growth of the nations. According to Akinbulire, Ola, Oluseyi, Awosope and Okoro(2008), there are few effects of unstable power supply on a nation as Nigeria, such as:

i. Inflation: Most establishments are run on the standby generators these days because of the irregularity in the supply of electricity power and whatever the goods and services delivered by these establishments, the money would pass down to the consumers of such goods and services. Interruption of electricity power results in damage to production lines in many factories which have made some of the manufacturers to embark on using the standby generators. Since most of these outages could occur several times in a day, then it is difficult for manufacturers to keep any form of faith with the utility, in order not to interrupt the production line activities, thus, the manufacturer's resorts to the private electricity generation.
ii. Several occurrences of the fire hazards that are recorded in factories and elsewhere are due to incessant power interruptions and fluctuations.
iii. During blackouts, it is very easy for robbers to operate in homes, and banks.
iv. Pollution caused by the fumes and noxious gases emitted by these standby generators can cause serious degradation to the environment and death to those who inhale them. Many lives have been lost to this hazard. Noise pollution from hundreds of generators cannot be overlooked.

Electricity access is an important factor which speeds up development in most economies of the world. Nigeria's access to electricity has been below economically acceptable level and has not been improved in recent times due to some obstacles, which include; low efficiency and performance, security of fuel source for power generation, data inadequacy, regulatory barriers, lack of institutional arrangement, poor grid structure, dilapidated transmission and distribution network, low financial investment, lack of policy, electricity generation is characterized by excess capacity and inadequate supply (Emovon, Kareem, & Adeyeri, 2011). It has been observed that peak demand is often about one-third of the installed capacity because of the non-availability of the spare parts and poor maintenance, a poorly-motivated workforce, vandalism and theft of cables and other vital equipment, accidental destruction of distribution lines, illegal connections and the resultant over-loading of the distribution lines, are additional major problems of the PHCN (Oluseyi, Akinbulire, Awosope, & Odekunle, 2009). These have been responsible for the unannounced load shedding, prolonged, and intermittent outages which most consumers of the electricity power in Nigeria have had to contend with over the years.

Electricity power generation in Nigeria rose from the few kilowatts that were used in Lagos by the colonial masters when the first generating plant was installed in 1898. By the Act of Parliament in 1951, the Electricity Corporation of Nigeria (ECN) was established. The Niger Dams Authority was set up in 1962 to develop the hydroelectricity and was merged with the ECN to form the National Electric Power Authority (NEPA) in 1972 (Emodi, Yusuf, & Boo, 2014). Despite the various efforts by the NEPA (which operated a monopolized market) to manage the power sector by providing electricity to the increasing population, it became clear that NEPA was losing the battle to meet up with the electricity demand in the 1990s. Consequently, in 2001, the National Electric Power Policy (NEPP) was introduced to kick-off the power sector reform and this led to several other reforms in the past years. The NEPP, in 2001, created the roadmap for the Nigeria's Power Sector Privatization, but due to government bureaucracy; the policy was not signed into law, until the 2005.

This signed document was the Electric Power Sector Reform (EPSR) Act in 2005, which was expected to level the playing ground for potential investors and improve the wellbeing of its citizens. The EPSR Act led to the incorporation of the Power Holding Company of Nigeria from the NEPA, which was later defunct and divided into sub-sectors (Emodi et al., 2014). The sub-sectors are made up of 18 companies which include: six generators (GENCOs), eleven (11) distributors (DISCOs), and one (1) Transmission Company (TCN). These companies are saddled with the responsibility of carrying out the functions relating to the generation, transmission, trading, distribution and bulk supply as well as the resale of electricity power in the country (Oseni, 2011).

Jos Electricity Distribution Plc, or Jos Disco, serves a significant industrial customer base in Bauchi, Benue, Gombe, and Plateau States, as well as Saminaka in Kaduna State. It owns and maintains the distribution network and support equipment within the Zone. Manages meter installations, servicing, and building; coordinates consumer credit services, and collects revenue. Jos Disco is one of the eleven (11) such distribution companies comprising the national distribution grid. The Transmission grid, in turn, is managed by a separate company, the Transmission Company of Nigeria (TCN) Plc, from the National Control Center at Oshogbo, and a supplementary Center at Shiroro.

The Jos Electricity Distribution or Jos Disco operates the traditional/manual methods of information handling and management of its electrical facilities and equipment. It is, therefore, highly required that an integrated system that supports digital mapping and creation of spatial database be implemented in order to overcome the inherent weaknesses of the current practice and provide timely, accurate and reliable information for prudent decision making and effective service delivery.

It is against the above background that this study undertakes to develop a decision Support System using the Geographic Information System (GIS) to aid the electricity power supply in Bukuru Town, with particular reference to the Jos Electricity Distribution Company, Plateau State.

1.2. Scope of Study

This study is meant to analyze the supply of electricity power in the study area with the view to enhancing sustainable development and management of power in the Bukuru Town, the capital of the Jos South Local Government Area. The study is confined to the existing electrical distribution network and facilities under the supervision of Bukuru business unit of Jos Electricity Distribution Company, which covers the transmission station, feeder station and substations, and the distribution transformers within the Bukuru Town. The study involved capturing the geometric and attributes data of the electrical facilities and creating a geodatabase for the features in each of the distribution transformers and the feeder stations. It also involved mapping the existing transmission network, the feeder station and the distribution transformers in the study area, and performing spatial analyses on the geodatabase created.

Bukuru is located on the Jos plateau in Nigeria, with a population of about 306.716 persons (NPC, 2007). It is usually considered a separate city from the city of Jos close by, but like every other form of urbanization, the city of Jos has merged with the town of Bukuru to form the Jos-Bukuru Town. It is the headquarters of the Jos South Local Government Area, located between Lat 09^{O} 38'& 09^{O} 54' N, and Long 08^{O} 42'& 08^{O} 58'E, (Figure 1) with the elevation ranging between 1.230m (4.040ft) and a peak of 1,829 meters above the sea level in the Shere Hills, With a total land area of 500.23 Sq Km (Adegboye, 2012).

Bukuru Town is endowed with rich deposits of a variety of industrial minerals of high quality. Tin (cassiterite) and columbite have been in the mining process in the region since 1902. Although, production has declined, due to a drastic fall in demand. This area was once the world's leading producer of tin with an annual output of 17,000 tons, in the peak war period of the 1941-45. Other minerals found in commercial quantities, are barytes, kaolin, zircon, monazite, marble, lime stone, sphalerite, quartz, galena, glass sand, clay, and gemstones, (Adegboye, 2012).

Existing industries in the region fall into two categories; cottage, and factory industries. They range in size, from small to very large, and depend entirely on imported machinery, and a combination of local and imported raw materials for their productions. These industries engage in various forms of manufacturing's which include food processing, production of packaging materials, cosmetics, furniture, confectioneries, livestock feeds, detergent, beer, soft drinks, pharmaceuticals, building materials, steel and metal sheets, book publishing, tin smelting, and lead materials. The cottage industries which are widely distributed throughout the region includes blacksmithing for making of simple tools, pottery, mat making, and leather works. Factory industries in the Plateau State are mostly concentrated in the region, such as the NASCO Group, Standard Biscuits, Grand Cereals and Oil Mills, Zuma steel west Africa, Aluminium Roofing industries, Jos International Breweries, among others. Jos south, also houses prestigious institutions such as the National Institute of Policy and Strategic Studies (NIPSS), the highest academic awarding institution in Nigeria, the National Veterinary

Research Institute, the Police Staff College, the NTA television college, and the Nigerian Film Corporation.(Plateau ReportCopy right, 2011)

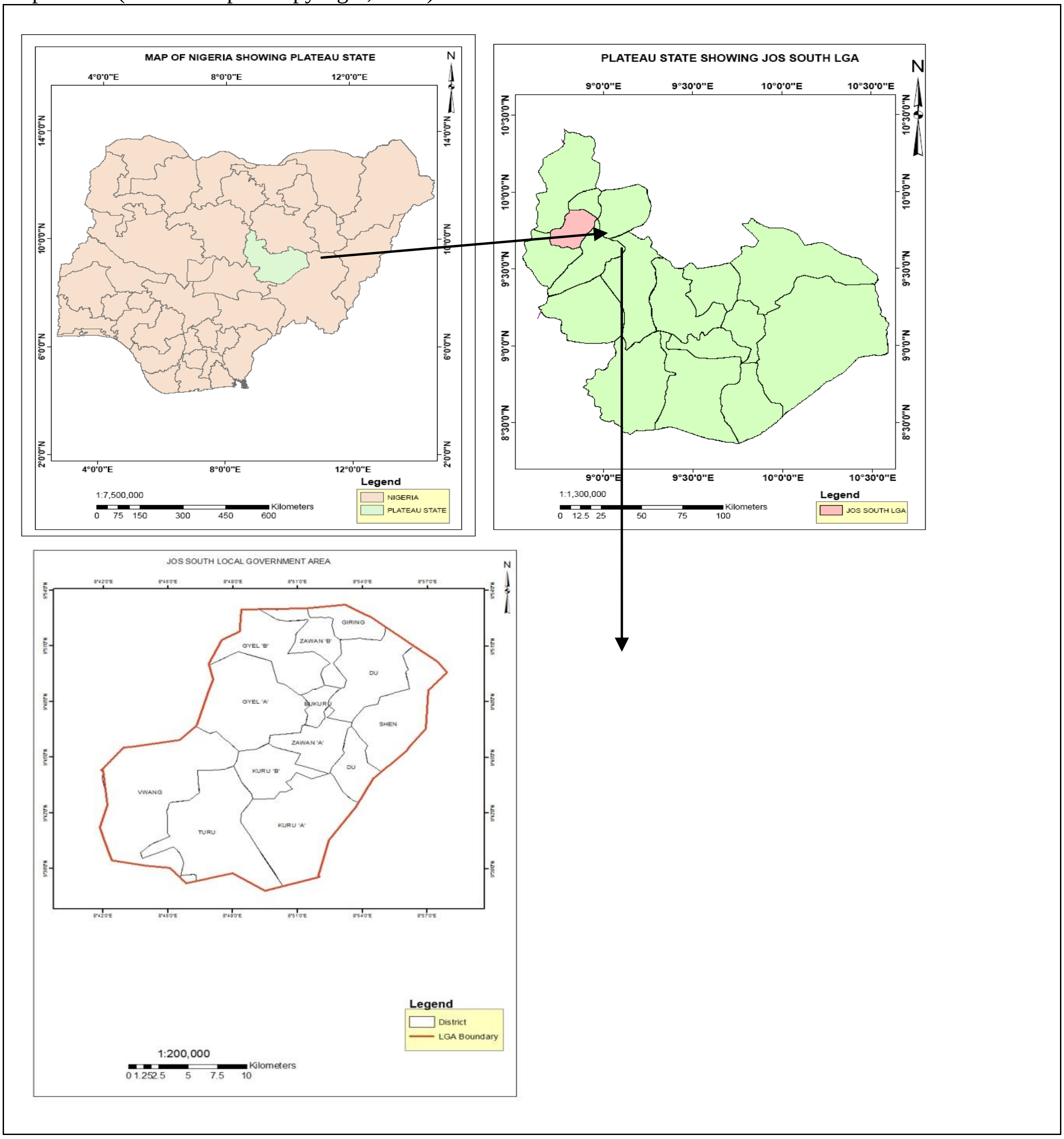

Figure1. Map showing Jos South Local Government Area

Source: Research work, 2020

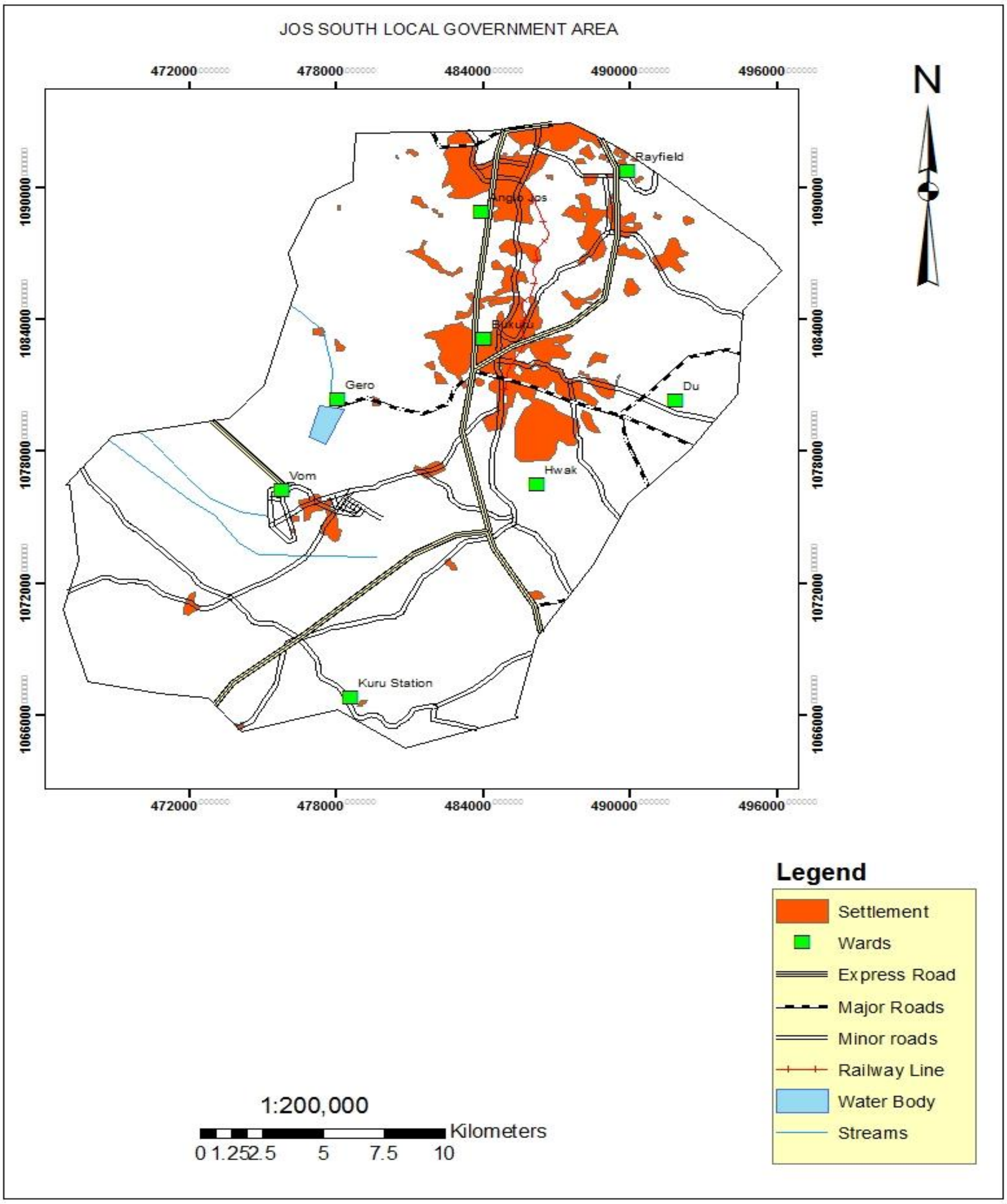

Figure2: The Study Area

Source: Research work, 2020

II. Data And Methods

This study involved two types of data; the spatial, and non-spatial (Attribute) data.

The spatial data involve using a satellite image of the area, which is made up of roads, buildings and facilities digitized from a Very High-Resolution Image data (Quick Bird 2010 satellite image of Jos Metropolis) and the X, Y Coordinate in the Universal Transverse Mercator (UTM) coordinate system taken from the GPS which is be placed at the bottom of transformers, feeders and each of the electricity poles to obtain their location.

The non-spatial data includes the following information acquired from the office of Jos Electricity Distribution Company, Bukuru Business Centre.

Electrical Network Details: 11 and 33kV line diagrams with cable sizes, lengths, distribution transformers (DT), parameters of the equipments, pillars, and poles.

Transformer Details: information on the amount of energy consumption, transformer capacity, make, year of production, location, and condition of the transformer.

2.1 Primary Data

The primary sources of data include The spatial data from the base map of the area, which consists of roads, buildings and electrical facilities digitized from a Very High-Resolution Image data (Quick Bird 2010 satellite image of Jos Metropolis) and. The X, Y Coordinate in Universal Transverse Mercator (UTM) coordinate system taken from a GPS which was placed at the bottom of transformers, feeders and each of the electric poles to obtain their location.

2.2 Secondary Data

The secondary sources of data include data obtained from books, journals, published and unpublished documents, magazines topographic map of Bukuru Town, Jos South Local Government Area.

Table 1: Data Specifications

Data Type	Scale/Resolution	Source
2010 Quick Bird, Satellite image Of Jos Metropolis	0.65m pixel	National Centre for Remote Sensing Jos
Topographic map of Jos South LGA	1:50,000	Jos ministry of Land and Survey
Monthly weather data (Temperature)		www.wunderground.com
Electricity distribution network map	1:5000	Jos Electricity Distribution Company
Record of Grid Energy consumption In Bukuru Town	(KWH)	Jos Electricity Distribution Company

2.3 Method of Data Analysis

In this study, relational database structure, search operation, Structured Query Language (SQL), buffering and regression and time series statistical modeling analysis was utilized, data was stored in a simple record known as tables, and each table contained an item of data called fields about a particular object. The objects was arranged along the rows and the field (attribute values) arranged along the column and the data structure was executed in the ArcGis software. The database created formed the information base in the Arc Catalog folder for easy recovery, geospatial analysis and queries.

The attribute tables were then linked to the spatial themes containing the geographic information.

The Photographs of distribution transformers, feeders, and transmitters taken with the camera was hyperlinked in the ArcGis environment to their various spatial locations on the digitized map.

The spatial search operation and query generation was carried out to retrieve information stored in the database pertaining to certain systematically defined attributes within the database to answer some spatially related questions. This operation involved the link between the database and the composite map of the project area. The queries generated provide answers to the research questions.

III. Results And Discussions

3.1 The geospatial distribution of the electricity power supply in Bukuru Town

The concept of power supply describes the planning and management procedure of the Electric Power Supply Systems running through the generation, transmission, distribution, retail and marketing sub-sectors of the supply system. In the figure (9) below, the electricity energy is generated at the generating plant and transmitted through the transmission network at high voltage (132/33 KV) line on Four Circuit Tower to a substation (Kara Transmission Station) located at Bukuru town. The network is divided into two parts, that is, Transmission system and Distribution system. Transmission lines, transmit bulk electrical power from sending end stations to receiving end stations without supplying any customer en route; by contrast, a distributor line or distributor supplies customers directly at short intervals along the line.

The distribution system is electrical system between the sub-station fed by the transmission system and the customer. It consists of distribution transformers, feeders, conductors and service mains. Feeders are conductors which connect the substation to the area where power is to be distributed, no tapping are taken from the feeder, distributors are conductors from which tapping are taken for supply to the consumers, services main are small cables which connects the distributors to the consumer’s terminals.

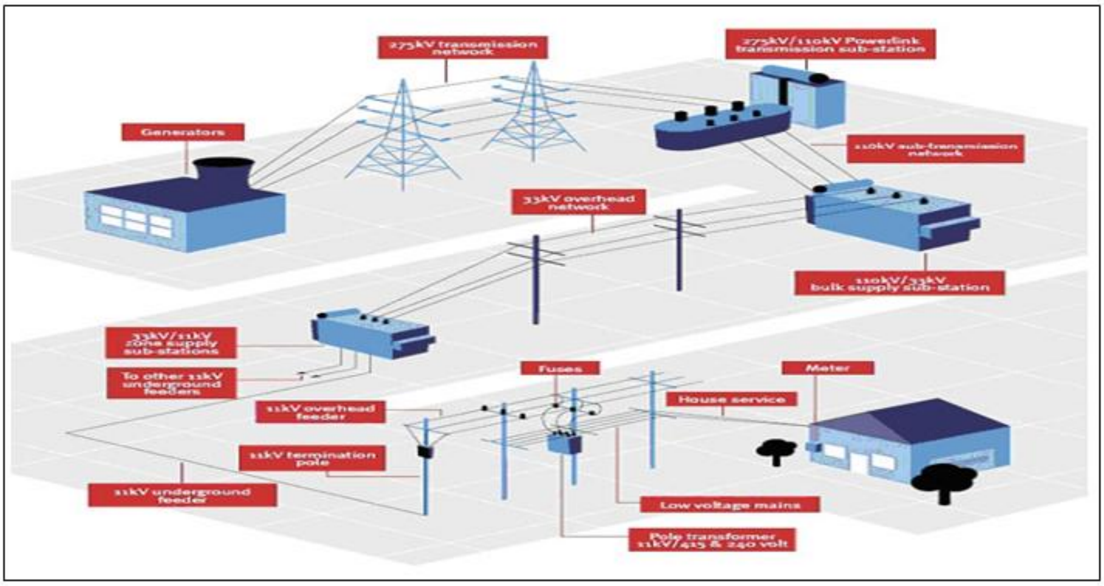

Plate 1: Electrical Power Supply Networks
Source: Makeri Transmission Centre. Bukuru

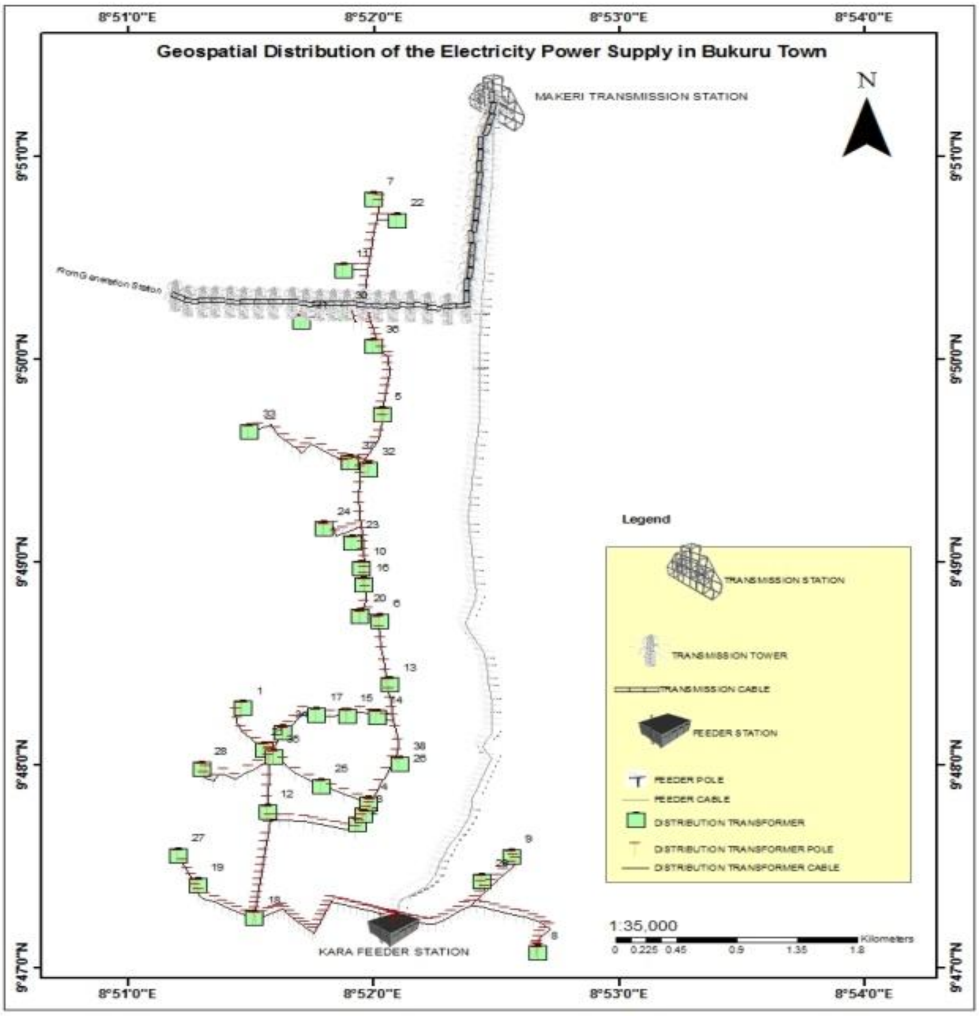

Figure 9: Map showing the geospatial distribution of electricity power supply in Bukuru town
Source: Author's Analysis, 2020

In the figure (10) below, (A) shows the distribution of electricity power from the generating station to a transmission centre, Depending on its design, a power supply may obtain energy from various types of energy sources, the Makeri Transmission Station receives power from any available generating plant through the interconnected lines known as a transmission network or grid. The Transmission grid, in turn, is managed by a separate company, the Transmission Company of Nigeria (TCN) Plc from a national control center at Oshogbo, and a supplementary center at Shiroro. In figure 10 (B), it shows the distribution of electricity power from the Transmission Station to the Feeder Substation at Kara in Bukuru Town, the energy received at the transmission centre at 132/33Kv is stepped down to 11Kv at the Feeder station before being distributed to the distribution transformers.

The distribution system is classified into two parts, that is, the primary distribution system, and the secondary distribution system. The primary distribution system supply power at high voltage to large consumers such as industrial customers and to distribution sub-stations. The most commonly used primary distribution voltages are the 11kv, 6.6kv and 3.3kv, 3 phase, 3-wire system. The secondary distribution system takes power to consumers such as residential customers at distribution voltage. The secondary employs 400/240 volts, 3 phase, 4-wire system.

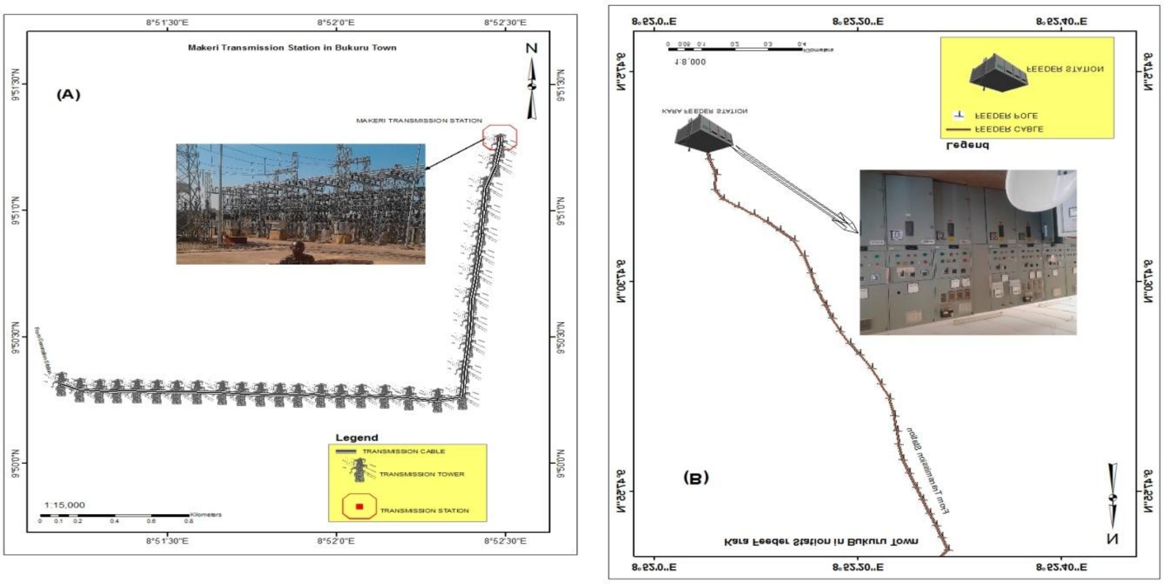

Figure 10: Map A and B Showing the Geospatial Distribution of Electricity Power Supply from the Transmission Station to the Feeder Station in Bukuru town.

Source: Author's Analysis, 2020

3.2 Geodatabase for the Power Supply Facilities

Appendix 1 shows the attribute data of the distribution transformers in Bukuru town, which includes the numbers, name, type, capacity, voltage ratio, service age, ownership record and the present condition of the transformers. The whole transformers have a total capacity of ten thousand (10,000) KVA. The primary goal of the database system is to provide the best quality data possible within a reasonable operation and providing consistent and acceptable documentation, and supporting the feedback of summary information to investigators for scrutiny. The database systematically arranged the collection of all the electric facility data and structured it so that it can be automatically retrieved or manipulated. The importance of creating the geo-database for the facilities involves:

i.) A controlled and standardized approach to data input and update, can be enforced with appropriate validation checks to ensure data integrity and consistency between the data files

ii.) Security restriction on access to specific data subsets can be applied.

A consistent approach can be adopted for managing simultaneous multi-user read and update operation on specific files or tables

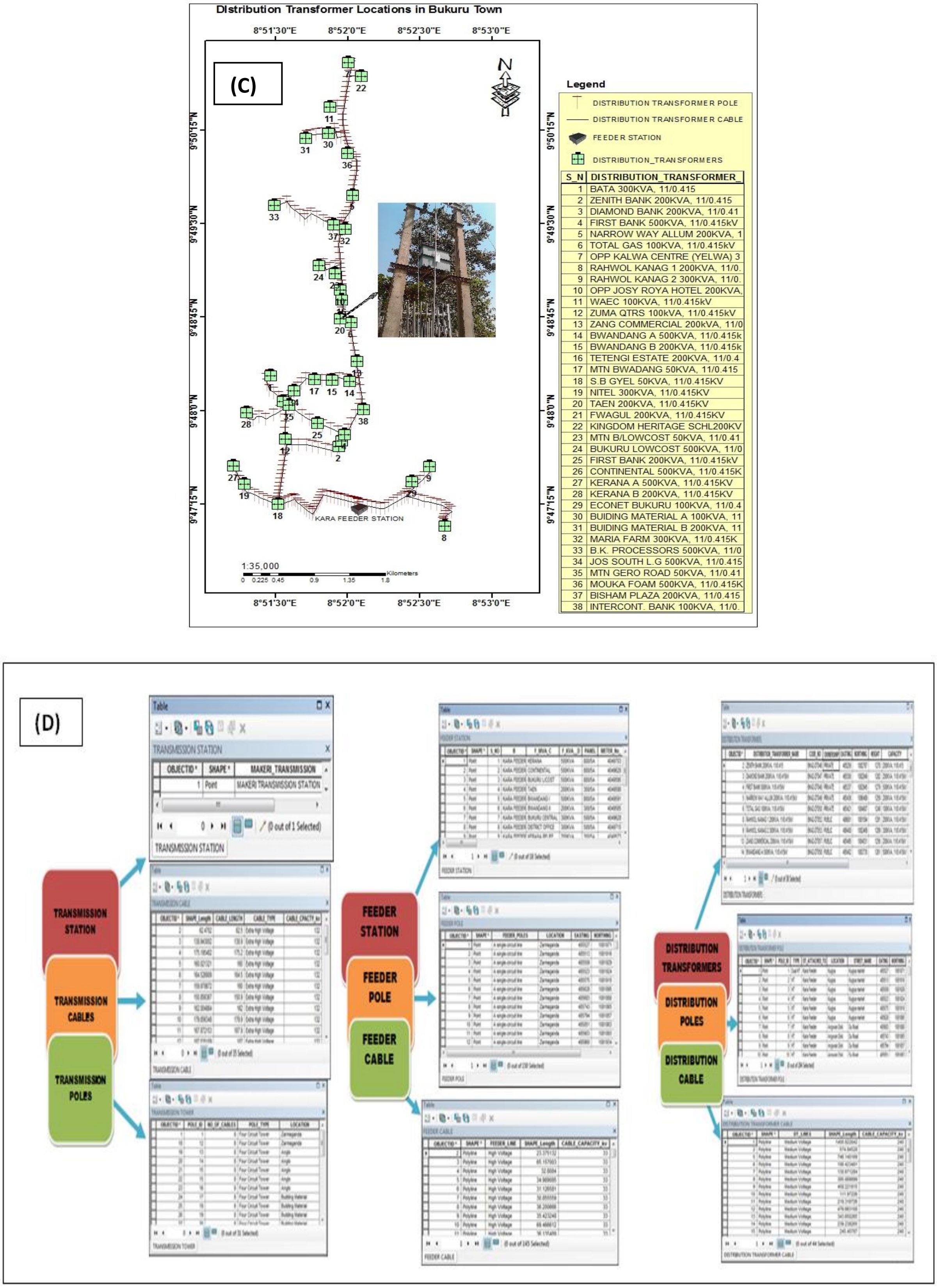

Figure 3: (C) and (D) Map Showing Geodatabase for the Geospatial Distribution of Electricity Power Supply in Bukuru town.

Source: Author's Analysis, 2020

Table 3.1 Asset Database Structure for the Distribution Transformers

S/No	TRANSFORMER NAME	MAKE	CAPACIY (KVA)	VOLTAGE RATIO	SERVICE AGE (YRS)	PRESENT CONDITION	OWNERSHIP
1	SHEN ROAD	LAPPER	500	11/0.415KV	22	OVERLOADED	PRIVATE
2	CHIKE DONALD	DEMINIT	200	11/0.415KV	11	GOOD	PRIVATE
3	BATA	SIEMENS	300	11/0.415KV	20	OVERLOADED	PRIVATE
4	ZENITH BANK	MITSUBISHI	200	11/0.415KV	4	GOOD	PRIVATE
5	DIAMOND BANK	-	200	11/0.415KV	6	GOOD	PUBLIC
6	FIRST BANK 1	-	500	11/0.415KV	22	OVERLOADED	PRIVATE
7	OCEANIC BANK	KONCAR		11/0.415KV	6	GOOD	PRIVATE
8	TOTAL GAS		100	11/0.415KV	20	GOOD	PRIVATE
9	WATER BOARD	MINEL	100	11/0.415KV	20	GOOD	PUBLIC
10	RAHWOL KANANG 1	MITSUBISHI	300	11/0.415KV	16	OVERLOADED	PUBLIC
11	RAHWOL KANANG 2	ELVIN		11/0.415KV	15	OVERLOADED	PUBLIC
12	RAWWOL KANANG 3	P/TRANSFOR	500	11/0.415KV	12	GOOD	PRIVATE
13	INTERCONT BANK	ABB	200	11/0.415KV	5	GOOD	PRIVATE
14	ZUMA QTRS	-	100	11/0.415KV	12	GOOD	PUBLIC
15	ZANG COMMERCIAL	-	200	11/0.415KV	18	OVERLOADED	PUBLIC
16	BWANDANG A	ELIIM	500	11/0.415KV	20	GOOD	PUBLIC
17	BWANDANG B	ABB	200	11/0.415KV	5	GOOD	PUBLIC
18	TETENGI ESTATE	SIEMENS	200	11/0.415KV	16	GOOD	PRIVATE
19	MTN BWANDANG	ELVIN	50	11/0.415KV	7	GOOD	PUBLIC
20	S.B GYEL	-	50	11/0.415KV	2	GOOD	PRIVATE
21	NITEL	NUCON	200	11/0.415KV	16	GOOD	PUBLIC
22	TAEN	-	200	11/0.415KV	15	GOOD	PUBLIC
23	FWAGUL	P/TRANSFOR	200	11/0.415KV	3	GOOD	PRIVATE
24	ITF		300	11/0.415KV	12	GOOD	PRIVATE
25	MTN B/LOWCOST	-	50	11/0.415KV	5	GOOD	PRIVATE
26	BUKURU LOWCOST	-	500	11/0.415KV	21	GOOD	PUBLIC
27	FIRST BANK 2	-	200	11/0.415KV	10	GOOD	PRIVATE
28	CONTINENTAL	-	500	11/0.415KV	17	GOOD	PUBLIC
29	KERANA A	OCREW	500	11/0.415KV	22	OVERLOADED	PUBLIC
30	KERANA B	NO PLATE	200	11/0.415KV	8	OVERLOADED	PUBLIC
31	ECONET BUKURU	JOHN HOLT	200	11/0.415KV	5	GOOD	PRIVATE
32	MISSION HOUSE	-	300	11/0.415KV	6	GOOD	PRIVATE
33	ANGWAN DABA	-	200	11/0.415KV	6	GOOD	PUBLIC
34	MARIA FARM	H	300	11/0.415KV	13	GOOD	PRIVATE
35	Building Material Mrkt		500	11/0.415KV	22	GOOD	PRIVATE
36	MTN GERO ROAD	ELIM	50	11/0.415KV	2	GOOD	PRIVATE
37	JOS SOUTH LGA	ABB	500	11/0.415KV	5	GOOD	PRIVATE
38	WAEC		100	11/0.415KV	5	GOOD	PRIVATE
TOTAL			**10,000**				

Source: Author's Analysis, 2020.

3.2 Spatial Search/Queries Generation

The distinction between Geographical information System and other Information Systems is in the area of spatial search/spatial analyses. Search operation is a GIS tool that is essential for processing or manipulating of data to suit user's need. The spatial search operation for this project was carried out through query generation to retrieve information stored in the database pertaining to certain systematically defined attributes within the database to answer some spatially related questions. This operation involved the link between the database and the composite map of the study area. Queries were generated to provide answer to the application use of GIS in managing the electricity power facilities and the results displayed in form of map.

Query 1: Search for a Particular Distribution Transformer in Bukuru Town

*QUERY SYNTAX: SELECT*FROM DISTRIBUTION_TRANSFORMER_NAME: WHERE: "NAME"= "MARIAH FARM 300KVA, 11/0.415KV"*

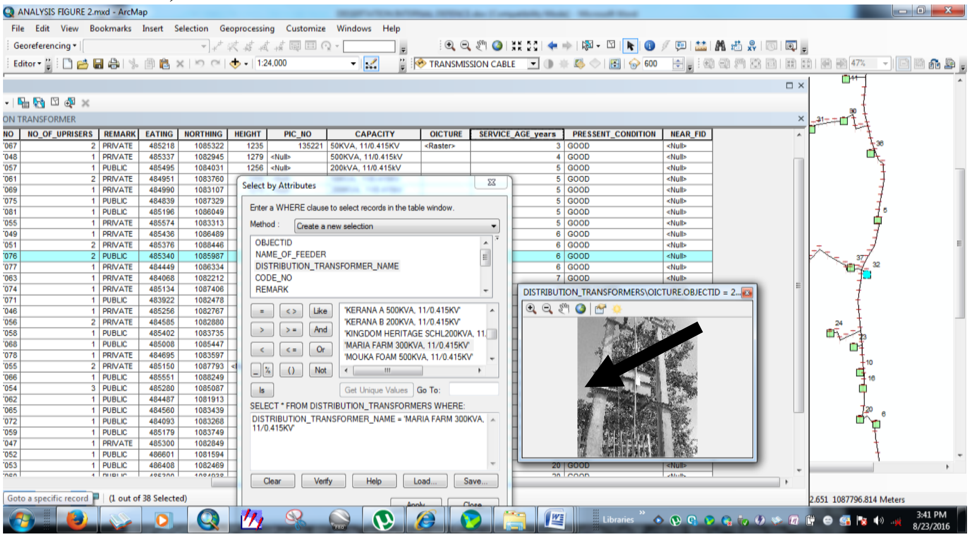

Figure 12: Result showing a query to display a particular distribution transformer details.
Source: Author's Analysis, 2020

The figure above displays detailed information generated through a query in the geo-database about a particular distribution transformer. Here it displays the distribution transformer name (Maria Farm), capacity (300kva, 11/0.415kv), spatial location (485340E, 1085987N), present condition (Good), service age (6 years), and ownership details (Public).

Query 2: Search for Distribution Transformers Present condition

*QUERY SYNTAX: SELECT*FROM DISTRIBUTION_TRANSFORMERS: WHERE: "PRESSENT_CONDITION"= "OVERLOADED"*

The spatial searches and queries below shows selection by attributes, which allow providing an SQL query expression that is used to select features that match the selection criteria.

In the table (7) below, the highlighted details shows about eight (8) overloaded transformers in the study area, these attributed to an in-sufficiency in supply of electricity power in the located transformers area due to overloading in the transformers as a results of the transformer's capacity being low to cater for the consumers need.

The table also shows that all the overloaded transformers are located at highly commercialized area, such as banks, filling stations and hotels where electricity is highly consume much more than the carrying capacity of the transformers in such location.

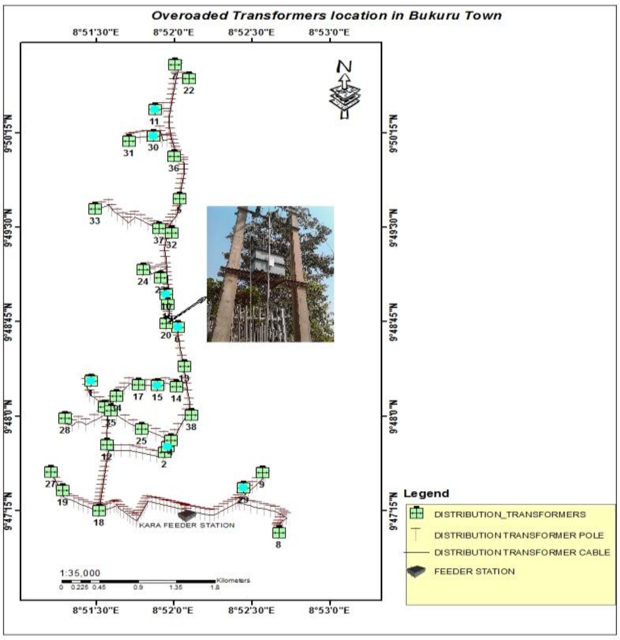

Figure 14: shows the spatial location of the overloaded transformers (Highlighted) generated by the query operation

Source: Author's Analysis, 2020

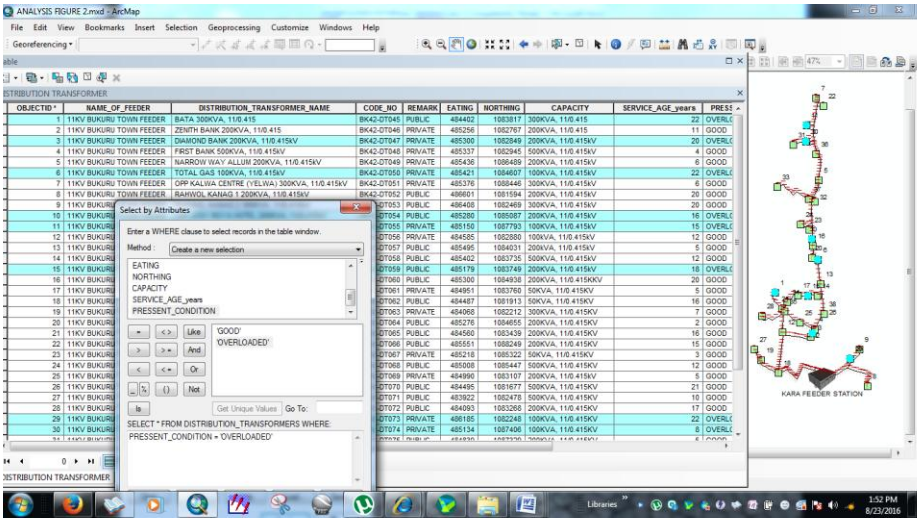

Figure 13: Result of query generated showing overloaded transformers

Source: Author's Analysis, 2020

Table 7: shows overloaded transformers detail (Highlighted) generated by the query operation

S/No	TRANSFORMER NAME	MAKE	CAPACIY (KVA)	VOLTAGE RATIO	SERVICE AGE (YRS)	PRESENT CONDITION	OWNERSHIP
1	SHEN ROAD	LAPPER DEMINIT	500	11/0.415KV	22	OVERLOADED	PRIVATE
2	BATA	MITSUBISHI	300	11/0.415KV	20	OVERLOADED	PRIVATE
3	FIRST BANK 1	KONCAR	500	11/0.415KV	22	OVERLOADED	PRIVATE
4	RAHWOL KANANG 1	ELVIN	300	11/0.415KV	16	OVERLOADED	PUBLIC
5	RAHWOL KANANG 2	P/TRANSFOR	200	11/0.415KV	15	OVERLOADED	PUBLIC
6	ZANG COMMERCIAL	ELIIM	200	11/0.415KV	18	OVERLOADED	PUBLIC
7	KERANA A	NO PLATE	500	11/0.415KV	22	OVERLOADED	PUBLIC
8	KERANA B	JOHN HOLT	200	11/0.415KV	8	OVERLOADED	PUBLIC

Source: Author's Analysis, 2020

Query 3: Search for Distribution Transformer Capacity
QUERY SYNTAX: SELECT*FROM DISTRIBUTION_TRANSFORMERS: WHERE: "CAPACITY"< "200KVA, 11/0.415"

In table (8) above, the query generated shows distribution transformer details that have capacity below 200KVA, the table shows that all the transformers below that capacity are privately owned. In figure (15) above shows the spatial distribution of transformers that have capacity below 200KVA, it shows about six (6) transformers being highlighted. It can also be seen that all the highlighted transformers are in good condition and privately owned, which suggest that private transformers are adequately utilized due to its less number of customers being attached to it than public transformers which are mostly in bad condition as a result of overloading, aged-equipments, and vandalization.

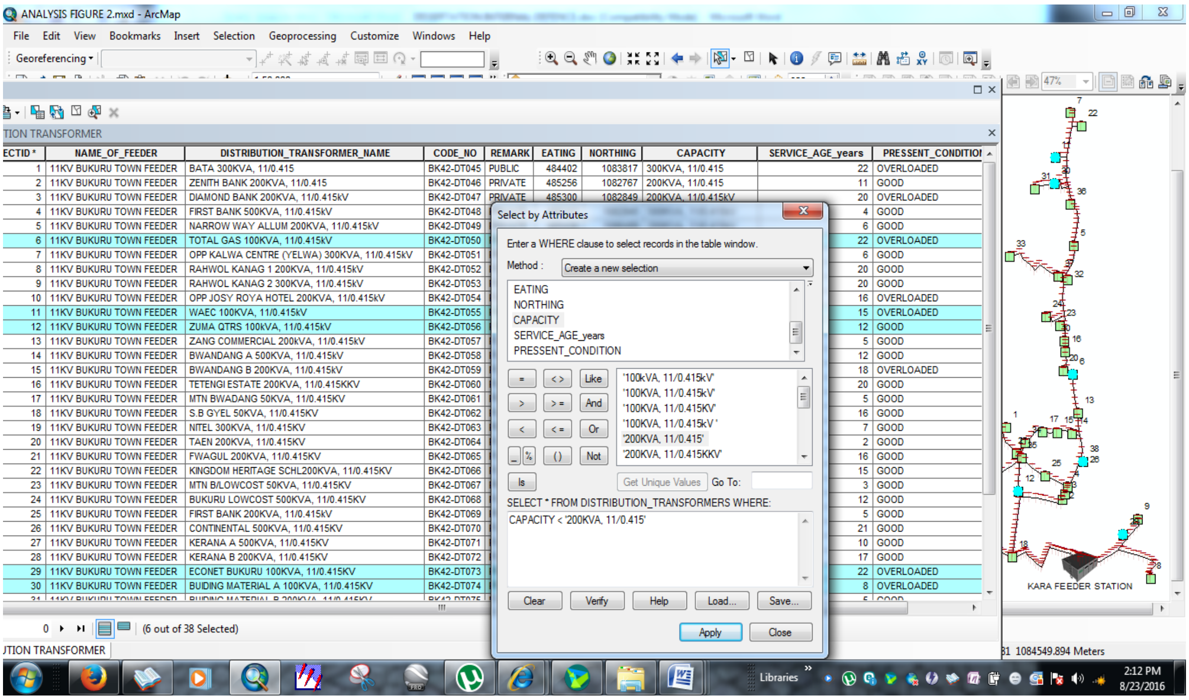

Figure 15: Result of query generated showing Distribution transformers capacity below 200KVA in Bukuru Town

Source: Author's Analysis, 2020.

Table — DISTRIBUTION_TRANSFORMERS

OBJECTID *	DISTRIBUTION_TRANSFORMER_	REMAR	EATING	NORTHIN	CAPACITY	SERVICE_AGE
12	ZUMA QTRS 100kVA, 11/0.415kV	PRIVAT	484585	1082880	100kVA, 11/0.415kV	12
6	TOTAL GAS 100KVA, 11/0.415kV	PRIVAT	485421	1084607	100KVA, 11/0.415kV	22
11	WAEC 100KVA, 11/0.415kV	PRIVAT	485150	1087793	100KVA, 11/0.415kV	15
38	INTERCONT. BANK 100KVA, 11/0.	PRIVAT	485574	1083313	100KVA, 11/0.415kV	5
29	ECONET BUKURU 100KVA, 11/0.4	PRIVAT	486185	1082248	100KVA, 11/0.415KV	22
30	BUIDING MATERIAL A 100KVA, 11	PRIVAT	485134	1087406	100KVA, 11/0.415KV	8
2	ZENITH BANK 200KVA, 11/0.415	PRIVAT	485256	1082767	200KVA, 11/0.415	11
16	TETENGI ESTATE 200KVA, 11/0.4	PUBLIC	485300	1084938	200KVA, 11/0.415KK	20
13	ZANG COMMERCIAL 200kVA, 11/0	PUBLIC	485495	1084031	200kVA, 11/0.415kV	5
3	DIAMOND BANK 200KVA, 11/0.41	PRIVAT	485300	1082849	200KVA, 11/0.415kV	20
5	NARROW WAY ALLUM 200KVA, 1	PRIVAT	485436	1086489	200KVA, 11/0.415kV	6
15	BWANDANG B 200KVA, 11/0.415k	PUBLIC	485179	1083749	200KVA, 11/0.415kV	18
25	FIRST BANK 200KVA, 11/0.415kV	PRIVAT	484990	1083107	200KVA, 11/0.415kV	5
8	RAHWOL KANAG 1 200KVA, 11/0.	PUBLIC	486601	1081594	200KVA, 11/0.415kV	20
10	OPP JOSY ROYA HOTEL 200KVA,	PUBLIC	485280	1085087	200KVA, 11/0.415kV	16
20	TAEN 200KVA, 11/0.415KV	PUBLIC	485276	1084655	200KVA, 11/0.415KV	2
21	FWAGUL 200KVA, 11/0.415KV	PUBLIC	484560	1083439	200KVA, 11/0.415KV	16
22	KINGDOM HERITAGE SCHL200KV	PUBLIC	485551	1088249	200KVA, 11/0.415KV	15
28	KERANA B 200KVA, 11/0.415KV	PUBLIC	484093	1083268	200KVA, 11/0.415KV	17
31	BUIDING MATERIAL B 200KVA, 11	PUBLIC	484839	1087329	200KVA, 11/0.415KV	5
37	BISHAM PLAZA 200KVA 11/0.415	PUBLIC	486196	1086049	200KVA 11/0.415KV	5

(6 out of 38 Selected)

DISTRIBUTION_TRANSFORMERS

Figure 8: shows List of Distribution Transformers (Highlighted) with capacity below 200KVA, generated by the query operation.

Source: Author's Analysis, 2020

IV. Conclusion and Recommendations

The study clearly indicates the capability of spatially enabled information system in the management of electricity distribution network. Spatial and attribute data of power distribution network of any part of the selected areas of interest in this study, which are presently acquired, processed, managed, stored and presented in analogue form, can be digitalized. Ayeni et al., (2003) noted that Geospatial Information (GI) is very essential to economic planning and national development. This is buttressed further by Alamu and Ejiobih (2002), when they concluded that a well maintained utility information infrastructure gives up-to-date information on what is where, the state of it, the reaction other actions on it would cause, how it can be harnessed for optimum use of the people and economy. It has been shown that GIS has been employed as one of the technologies for better and improved delivery of networked services.

The spatial analysis and the resulting maps provided a better knowledge and understanding on spatial relationships among electricity facilities and consumer demands. Such knowledge is expected to help in knowing the sections of the service area that lack adequate services. It is also expected to serve as a guide in order to know where they could extend or improve their services and areas that need new installation based on the distribution of power.

Conclusively, this further enlightens that regardless of cost, GIS has prominently improved the manner of service delivery with respect to time period.

5.1 Recommendations

The following recommendations are outlined by the study:

i. This study was only confined to distribution transformer level, further research to include residential area of distribution system is highly recommended.
ii. The user requirement and survey analysis conducted before implementation of electricity projects should include spatial information system from the onset so as to forestall drop in voltage within the distribution network
iii. More efforts must be made to bring in refined and scientific approaches such as Geographic Information Systems into the management of electricity distribution network.

Conflict of Interest Statement

Authors declare no conflict of interest.

Authorship

Author 1. Made substantial contributions to conception and design, literature review, data analysis, validation of results, interpretation of results and discussions (intellectual content), drafting the manuscript, collation of the final version to be published article.
Author 2. Made substantial contributions to conception and ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved
Author 3. Field work, made substantial contributions to conception, and design and revising manuscript
Author 4. Field work, made substantial contributions to conception, and design and revising manuscript
Author 5. Field work, data analysis, referencing and accountability for all aspects of the work

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